Hitotsubashi Journal of Economics 60 (2019), pp.21-40. © Hitotsubashi University

REVERSE MORTGAGES FOR MANAGING LONGEVITY RISK IN KOREA

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Received October 2017; Accepted August 2018

Abstract

This study examines how longevity risk can be alleviated by using reverse mortgage loan system in Korea, Joo-Taek-Yeon-Keum (JTYK). We compare the expected utility value of JTYK borrowers during retirement with that of non-JTYK borrowers, and identify characteristics of groups earning the greatest benefits from the JTYK. The results imply that it is especially beneficial for homeowners aged 67 and older, and its benefit increases if the bequest value is included. We also calculate the Money's Worth Ratio (MWR) of the JTYK, and show that MWRs increase as the opt-in age increases if the bequest is considered as financial gain.

Keywords: reverse mortgage, longevity risk, expected utility function, optimization, bequest
JEL Classification Codes: C61, D14, G22

I. *Introduction*

Korea is experiencing the fastest rate of population aging in the world. The rate of aging in Korea is the fastest among the Organization for Economic Co-operation and Development (OECD) member countries. According to Statistics Korea (KOSTAT), the percentage of the elderly aged 65 and older among the total population was 12.7%, which represents 20.1% of households in 2014, and is expected to rise to 19.0% and 27.6% in 2024 and 2034, respectively. In addition, according to the social survey conducted by KOSTAT in 2010, 38.5%

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of the baby boomers born between 1955-1963 have the Korean National Pension (KNP) as the sole source of their retirement income (www.kostat.go.kr). This rapidly aging population without adequate wealth for retirement induces an increased longevity risk, i.e., the risk of outliving one's resources (MacMinn et al., 2006; Stallard, 2006). Thus, it is important for retirees to efficiently manage financial resources and seek diverse alternatives to hedge longevity risk (Heo et al., 2016).

Among elderly households, housing wealth represents a large fraction of their total assets. On average, elderly households hold 78.4% in non-financial assets among total assets, and 41.8% of total assets are housing assets in Korea (Shyn, 2016). Hence, the reverse mortgage loan system in Korea, known as Joo-Taek-Yeon-Keum (JTYK), represents a valuable option for Korean retirees to support their financial needs during retirement, and may help to reduce longevity risk. The JTYK was first introduced in Korea in July, 2007. Subsequently, it has experienced phenomenal growth and after only 7 years, more than 25,699 people had obtained the JTYK as of June, 2015 (KHFC, 2015). Furthermore, in the first half of 2015, the number of people who obtained the JTYK increased by 24% compared to the same period in 2014. Considering these trends, it is expected that the JTYK becomes one of the major means to financially prepare for retirement among Korean adults.

If the owner of a house utilize the JTYK, the owner and the spouse receive monthly payouts for life. If the couple dies prematurely before receiving total payout equal to the value of the house, their heirs receive the residual value as a bequest. This study investigates the effect of the bequest motive in valuing the JTYK in terms of utility. Most studies concerning the value of annuities or reverse mortgage loans are based on models lacking bequest motives. In this study, we examine how longevity risk can be alleviated using the JTYK considering the bequest in the valuation model. We evaluate the financial value of the JTYK by calculating the money's worth ratio (MWR) with bequest as well as without bequest. Then, we compare the expected utility value of the JTYK during retirement with that of non-JTYK borrowers, and identify characteristics of the groups which receive benefits from the JTYK in terms of expected utility value. For the analysis, ANOVA (analysis of variance) and multi-variate regression analysis were performed. Also, we assume that residual assets after the deaths of the couple are bequeathed to their heirs, and this utility is included as a part of the total expected utility value.

This study is different from previous studies concerning the JTYK in Korea. First, we evaluate the JTYK using a utility-based optimization model utilizing the framework of the life-cycle model of consumption. Several previous studies (e.g. Ma and Den, 2006; 2013) evaluated the JTYK solely from a financial point of view. Second, the mechanism of the inheritance process of the JTYK is included in our model. Previous studies have assumed that there is no bequest with the JTYK, and heirs cannot receive compensation even if the parents who utilized the JTYK died well before total payments reach the house value (Yuh, 2013; Yang et al., 2014; Yang and Yuh, 2014; Yuh and Yang, 2016). However, in reality heirs can claim bequest of the house if both parents' death has left residual value of the house after deducting appropriate transaction fees. In addition, we include financial analysis of the JTYK including the bequest. We believe that our results are more conclusive than previous studies by including the bequest consideration in the model. Third, this study uses the newest datasets concerning retirees, including house values, assets, and types of annuities.

In the next section, we review relevant previous studies. In Section 3, we describe methodology used in this paper, including data, assumptions and parameters. In Section 4, we present the main results and discuss their implications. Finally, we conclude the paper with the summary and policy implications.

II. *An Overview of the Previous Literature*

1. Reverse Mortgages

A reverse mortgage could act as an additional source of income by converting wealth to cash flow. There are several studies regarding the reverse mortgage loan system, and most originate in developed countries such as the U.S., Australia, and the EU. Results regarding potential demand of reverse mortgages in the U.S. can be found in Merill et al. (1994) and Rasmussen et al. (1995). Merill et al. (1994) identified the group receiving the greatest benefit from reverse mortgages. In analyzing the potential size of the reverse mortgage market, Rasmussen et al. (1995) noted that many households would receive substantial benefits from monthly reverse mortgage payments. In addition, Rasmussen et al. (1997) suggested that approximately 80% of older homeowners may benefit from obtaining reverse mortgage loans. However, even though the reverse mortgage market grew substantially in the mid-2000s, very few eligible homeowners have used reverse mortgage loans to benefit from the additional cash flow (Shan, 2011). In fact, only 2.1% of eligible homeowners had reverse mortgage loans in 2011, despite the growth in the market (Nakajima and Telyukova, 2014). Similarly, Chatterjee (2016) noted that very few homeowners participated in the reverse mortgage market, and homeowners younger than 67 are less likely to have reverse mortgage loans. These studies have mainly focused on factors associated with elderly homeowners' decision to take out the reverse mortgage loan.

Similar studies were conducted in other countries. Costa-font et al. (2010) empirically examined the willingness of senior citizens to obtain reverse mortgage loans in Spain and found that decisions were largely dependent on income and education levels. Ong (2008) emphasized the benefits of reverse mortgage loans in Australia and identified groups receiving the greatest benefits from reverse mortgages. Reed and Giber (2003) compared reverse mortgage loans in Australia with those in the U.S. and discussed the strengths and weaknesses of reverse mortgages. A similar study was conducted in Hong Kong and results suggest that homeowners without children and possession of financial assets were more inclined to apply for reverse mortgage loans, while the amount of financial assets was negatively associated with receiving reverse mortgage loans (Chou et al., 2006). Mitchell and Piggot (2004) identified the factors to stimulate the reverse mortgage loan system in Japan, and suggested several policies. In Japan, while the reverse mortgage loan system was introduced in 1981, the reverse mortgage market has been underutilized, with less than 300 loans granted annually (Koh, 2016).

In Korea, the reverse mortgage loan system was introduced in 2007 as a government guaranteed scheme for elderly homeowners, and has grown substantially during the last few years. In fact, during the first five months of 2016, the number of new loans increased 174.9% compared to the same period in 2015 (Shin, 2016). Despite this recent phenomenal growth, only about 1% of eligible homeowners have received reverse mortgage loans, and hence we may see more future growth (Shin, 2016). Also, there are several studies regarding the potential demand and factors related to the elderly homeowners' decision to obtain reverse mortgage loans (Kim and Ma, 2011; Ahn et al., 2013; Lee and Park, 2014).

2. The Valuation of Reverse Mortgage Loan System

There are few studies which focus specifically on the valuation of a reverse mortgage loan system. However, the structure of the reverse mortgage loan system is similar to that of annuities, and hence, we will initially discuss the literature concerning the valuation of annuities.

Several attempts have been made to evaluate annuities based purely on financial measures. For instance, many actuarial and insurance studies use internal rate of return (IRR) concepts to evaluate annuities and other forms of life insurance (i.e., Broverman, 1986). Other studies employ implied longevity yield (ILY), which is equal to the IRR over a fixed deferral period that an individual would have to earn on their investable wealth if they decide to self-annuitize using a systematic withdrawal plan (i.e., Mielvsky, 2005). Another commonly used financial measure for estimating the value of an annuity is the money's worth ratio (MWR), which is defined as the ratio of the expected net present value of all payouts to the premium paid for the annuity (Brown, 2007; Friedman and Warshawsky, 1988, 1990; Mitchell et al., 1999; Warshawsky, 1988).

To overcome the limitation posed by overly simple financial measurements, several studies have employed a utility-based optimization model with the framework of a life-cycle model of consumption to measure the value of annuities. Most previous studies that have employed a utility-based optimization model use numerical optimization techniques to calculate either the wealth equivalent of an annuity or the annuity equivalent wealth (AEW) (Gong and Webb, 2008). Brown and Poterba (2000) examine joint-life annuity products for married couples and analyze the potential utility that an actuarially fair annuity provide for couples.

There have been several studies which have evaluated the reverse mortgage loan system by analyzing its payments structure. Ma and Deng (2006) developed an insurance structure of the reverse mortgage loan system in Korea. By using the total annual loan cost measures, they determined the value of the JTYK and showed that the gradual increasing monthly payments approach is more efficient than the constant monthly payments approach. A similar result was also found in Ma and Deng (2013). Lee et al. (2012) developed an analytic valuation framework for the reverse mortgage loan system with lifetime payments. Conditional on the level of interest rates, Lee et al. (2012) proposed a closed-form solution for reverse annuity mortgage insurance. Tsay et al. (2014) evaluated the reverse mortgage loan system by using an approximate pricing formula, and claimed their results approximated those from the simulation. Recently, Kim and Li (2016) determined the value of non-recourse protection of the JTYK by using a multi-variate model and suggested ways of improving the fee structure. Their goal was to evaluate the structure of the JTYK in order to reduce possible risks associated with non-recourse protection for the provider. These studies in addition to others, such as Wang et al. (2016), tried to evaluate the reverse mortgage loan system financially by analyzing payment streams without considering the overall financial situation of loan recipients.

To overcome this limitation, some studies have evaluated reverse mortgage loans using a utility-based optimization model, which is similar to the one used by studies such as Brown and Poterba (2000), and Gong and Webb (2008). Yuh (2013), and Yang et al. (2014) evaluated the

JTYK using AEW, which is a widely used measurement to evaluate annuities (e.g., Brown and Poterba, 2000). Also, Yang et al. (2014) used a modified AEW to introduce a new measurement called RMEA (Reverse Mortgage Equivalent Annuity) to evaluate the JTYK. Meanwhile, Yang and Yuh (2015), and Yuh and Yang (2016), did not use additional measurements like AEW and RMEA, but instead calculated expected utility value during the retirement period in order to evaluate the JTYK. This is due to these two studies focusing on the difference of utility values between the case with the JTYK and cases without the JTYK.

3. Alleviation of Longevity Risk Using the Reverse Mortgage Loan System

The reverse mortgage is a financial tool for tapping housing equity for various purposes and at various stages in life cycles. One of the primary roles of reverse mortgage loans is to help elderly homeowners sustain consumption later in life, i.e., to alleviate longevity risk (Rasmussen et al., 1997). Even though some forms of the reverse mortgage loan system, such as Home Equity Conversion Mortgages (HECM) in the U.S. and the JTYK in Korea, are clear examples of insurance to protect the elderly from longevity risk, research directly addressing the role of reverse mortgages for alleviating longevity risk is scarce[1].

Recently, Yang and Yuh (2014) examined the role of reverse mortgages to alleviate longevity risk. Specifically, they first calculated the maximum expected utility values by assuming that (1) the household utilizes the JTYK and (2) the household does not utilize the JTYK and self-annuitizes wealth. Subsequently, they defined the differences of utility values from the two assumptions as the alleviation of longevity risk from obtaining the JTYK. They identified factors of groups earning the greatest benefits from the JTYK, but they did not consider the bequest motive even though the JTYK allows the residual value after death of the couple to be bequeathed to heirs. Yuh and Yang (2016) performed a similar analysis to examine the existence of longevity risk alleviation differences between a single male and a single female householder with the JTYK. Their analysis mainly focuses on gender difference in longevity risk alleviation. The analysis in this paper is similar to Yang and Yuh (2014). However, we enhance the life cycle model significantly by including the bequest motive and add the financial valuation of the JTYK.

4. Bequest Motives and Other Characteristics Affecting Demand of JTYK

Much evidence exists that the bequest motive is important in explaining individual saving behavior and wealth accumulation of the elderly. Some studies have estimated that about 80% of household wealth is inherited, indicating that bequests are an important component in aggregate wealth accumulation (Kotlikoff and Summers, 1981; Menchick and Martin, 1983). Meanwhile, bequest motives have been identified as one of the major reasons for explaining the annuity puzzle. It is expected that people with plausible bequest motives should annuitize part of their wealth. Thus, bequest motives cannot explain why most people do not annuitize any wealth (Lockwood, 2012).

Including the bequest motive in valuing annuities can be complicated since beneficiaries

[1] Some studies discuss the securitization of longevity risk but in this case, the longevity risk is from the provider's perspective (e.g., Wang et al., 2008).

are not the people who obtained the annuities. However, Brown and Poterba (2000) notice the importance of calibrating the effect of bequest motives on the demand for joint and survivor annuities. In addition, Brown (2003) suggests that even though the economics profession does not have a consensus concerning the importance of bequests or how to effectively model them, a study that furthers the understanding of the value of annuities with bequest options would be valuable.

Some studies have specifically examined the importance of the bequest motive in Korea. While Chung (2002) notes that traditional life cycle models generally do not include the bequest motive, she developed two separate life cycle models for the pre-retirement and post-retirement periods. By analyzing surveys of 324 Korean retirees, she concludes that the bequest motive is a significant factor determining the utility level of individuals. Furthermore, Song (2009) analyzed data from the 2004 Korea National Survey of the Actual Conditions and Welfare Demand of the Elderly, and provides evidence that 88.5% of Korean retirees over 60 years of age aspire to save more money in order to receive better care from their descendants. She argues that the holding of wealth implies the expectation of better attitudes from descendants towards their parents, and also that the Korean elderly possess the exchange (or strategic) bequest motives suggested by Bernheim et al. (1985). Also, many Korean parents desire leaving their houses to heirs as inheritance, or help children purchase a house (Nam, 2006; Yoon, 2005). We may conclude from previous studies that due to the strong influence of tradition, Koreans have a strong tendency to save money to bequeath to children and in exchange, expect caregiving from children.

Several studies have also addressed what type of elderly households most benefit from reverse mortgages. Some characteristics have been identified as influencing the potential value of reverse mortgages to elderly homeowners. First, the most important characteristic is that a household has a combination of low or moderate income and a reasonable level of net equity (for example, at least the median or mean level of equity). Elderly homeowners with relatively low income are more likely to view a given payment level as a meaningful supplement to their income. Elderly homeowners with both low income and relatively high equity can receive substantial benefits from reverse mortgage programs. Second, the most beneficial impact is for those aged 75 and older, due to receiving larger payments. Third, households who have been in their homes for many years are likely to want to remain there (Merrill, Finkel, and Kutty, 1994).

Additionally, a recent study found that house price appreciation may have contributed to the rapid growth in the reverse mortgage market in the mid-2000s in the U.S. (Shan, 2011). In addition, sharp decline in house prices have important implications to the reverse mortgage market. Lower house prices imply higher cost for governments to provide fixed payments, especially on loans originating when house prices were near their peak (Shan, 2011).

III. *Methodology*

1. Data

For analysis, we used data from the KReIS from the National Pension Research Institute and extracted relevant demographic data concerning homeowners aged 60-70. The JTYK is eligible only for house values lower than or equal to 0.9 Billion Korean Won (approximately 820,000 USD). Hence, we used the house value as a filter to extract data. In total, data from 233 households was collected and used for analysis. Data used for analysis includes house values, other assets, and types of annuities. If a household has debt, we first subtract the debt from other assets. Similarly, if other assets are exhausted, then the remaining debts may be subtracted from the house value. Lastly, if a household receives any type of annuity including public pension, then it is also included in the model as annual income. For the case that a household owner utilizes the JTYK, the monthly payout streams from the KHFC (Korea Housing Finance Corporation) were obtained through the KHFC website.

2. Research Model

We begin by describing the cohort-specific life table, which is used in the analysis of the financial and utility value of the JTYK. Then, we discuss how we obtain the JTYK payout streams from the KHFC website. Also, we introduce the MWR, which is a commonly used measurement to financially evaluate annuities, and employ the life-cycle optimization model with the objective of maximizing the expected utility from consumption and bequests. Finally, we measure the alleviation in longevity risk.

The general analysis approach used in this paper is similar to that in Yang and Yuh (2014), and Yuh and Yang (2016). However, we extend the previous model by including the bequest motive of elderly couples and consider the financial valuation of the JTYK in addition to the utility-based evaluation. All monetary values in the model are converted to USD using an exchange rate of USD 1=1,100 KRW for simplicity and ease of exposition[2].

1) Cohort-specific Life Table

We calculate cohort-specific mortality rates for both males and females born between 1942-1952. In order to obtain the utility values, it is critical to use a cohort-specific life table instead of a regular life table for a certain year. Since it was impossible to obtain raw cohort mortality rate data for age-specific groups in Korea, we used past population census data and the future population data of the target cohort from KOSTAT to estimate the cohort-specific mortality rates[3]. Fortunately, data was available for age-specific cohorts and thus, we could estimate mortality rates for the target cohort. Furthermore, estimation of mortality rates was necessary due to the absence of age-specific population data following the year 2060[4].

To estimate male and female mortality rates, ($q_{x,m}$, $q_{x,f}$), we used the following equation used in Brown et al. (2002) and Brown (2003):

$$q_{x,f}=\frac{P_{x,f}-P_{x+1,f}}{P_{x,f}}.$$

[2] As of September 5, 2016, USD 1=1,106 KRW.

[3] This population census data may not be perfect for estimating the mortality rates due to the existence of the international migration.

[4] We used the estimation method used by KOSTAT. KOSTAT assumes that $q_x=q_{x-1}e^{ax+b}$ for successive mortality rates after the age of 85, where a and b are estimated through regression. We use this method to calculate the mortality rate after the year 2060.

where $P_{x,f}$ and $P_{x+1,f}$ are population of females with ages x and $x+1$, respectively, and $q_{x,f}$ is the probability that a female aged x dies before she becomes $x+1$ years old.

After we obtain the mortality rates for men and women in the target cohort, we smooth the data using a nonlinear model for age-specific mortality rates regarding each group. As suggested in Brown et al. (2002) and Brown (2003), we apply the Gompertz-Makeham survival function to obtain fitted estimates for mortality rates for a particular group regarding a specific age. The three parameters, a, b, and c, used in the Gompertz-Makeham survival function are estimated using nonlinear least squares regression as follows:

$$q_{x,f}=1-sg^{(c^{x+1}-c^{x})}.$$

2) Estimating the JTYK Payout Streams from the KHFC

In order to evaluate the JTYK, the payout streams from the KHFC should be estimated. This can be done through the KHFC website (www.hf.go.kr). Data used in this research include people born between 1942-1952. Note that their age ranges from 60-70 at the time of the survey conducted in 2013. Hence, it is necessary to adjust each subject's birth year by four years in order to determine the correct payout streams. For example, regarding a 70-year-old subject, we used January 1st, 1946, as their birthday instead of January 1st, 1942. Similarly for a 60-year-old subject, we used January 1st, 1956, as their birthday. For simplicity, we assume that each subject has a partner with the same age. The KHFC has three different payment streams for applicants. One is the fixed payment scheme, which provides a fixed monthly payout to borrowers until the death of both members of the couple. The second stream is the large-earlier-small-later scheme, or simply a two-phase scheme, which provides a slightly larger amount than the payout of the fixed payment scheme for the first 10 years, and then 70% for the remaining years. The third stream 'preferential' is for a special case in which value of the house is less than about 0.136 million dollars. It is basically identical to the fixed payment scheme except borrowers receive a larger fixed monthly payout during their retirement period[5].

If the couple dies prior to the total payout reaching the value of the house, the KHFC provides the residual value of the house to heirs after deducting appropriate interests and fees. Hence, the bequest amount is calculated according to the rules provided by the KHFC and is used in both financial and utility based evaluations of the JTYK.

3) Financial Measurement: MWR (Money's Worth Ratio)

Using the value of the house, the payout streams from the KHFC, and mortality rates[6], we calculate the MWR, which is a commonly-used financial measurement for evaluating annuities (Brown, 2007). In this paper, we use the MWR to determine the value of the JTYK. To calculate the MWR, we first calculate the NPV of the total payouts from the KHFC. The MWR can be defined as follows:

$$\text{MWR}=\frac{\text{Expected NPV of total payouts}}{\text{Value of a house}}.$$

[5] The KHFC actually offers additional schemes including the schemes with lending a fixed amount of money to borrowers. However, as of 2015, 82.5% of borrowers chose a pure life annuity type scheme.

[6] The probability of survival can be easily calculated from the mortality rate.

Note that the numerator is the sum of all future payments from KHFC and the bequeathed amount, weighted by the probability that at least one of the married couple will be alive to receive payments and discounted back to the present (or the time of retirement) using a nominal interest rate. Similarly, the denominator is the value of the house which is determined at the time of applying for the JTYK. If the MWR is less than 1.0, then this implies that on average, a couple who obtains the JTYK will receive less in total payouts than their current house value.

4) Utility-based Measures

We introduce a multi-period optimization model to calculate the maximum expected utility from the personal consumption. The optimization model is similar to that used in Yang and Yuh (2014). The main difference is that our model includes the utility from the bequest in addition to the utility from consumption.

For the case in which a couple borrows using the JTYK, the model assumes that they have a non-annuitized net wealth W_0, which includes all wealth except for their house and the JTYK payout stream at the time of retirement. For the other case in which a couple does not borrow using the JTYK, the model assumes that a couple have a non-annuitized net wealth W_0, which includes all wealth at the time of retirement. We also assume that they may or may not have pre-existing annuities depending on their actual situation. In order to include the condition that a couple bequeaths house value to heirs upon death, we need to modify the consumption-based utility function in the optimization model. The bequeathed amount can be calculated depending on age and status of the JTYK. For simplicity, we assume that the utility function applied for the bequest is identical to the utility function that is applied for the investor's own consumption when alive, as in Cocco et al. (2005). It is also assumed that all assets except the house can be easily liquidated and used for consumption. Finally, we assume that all monetary values in the model are in nominal terms[7].

Generally, it is difficult to obtain a closed-form solution for utility in a multi-period setting with liquidity constraints that are imposed by the annuity structure. In such cases, one solution for the optimal utility is to use the DP (Dynamic Programming) techniques; we use the DP to solve for the optimal consumption path and bequest amount[8]. To apply the DP technique, we use a recursively defined value function $V_t(W_t)$ where W_t denotes the non-pension assets at time t.

5) Measurement of Longevity Risk Alleviation

In order to measure longevity risk alleviation, the following measurements are introduced:

$$Y = V(RM) - V(SA).$$

$$YP = \frac{V(RM) - V(SA)}{V(SA)}.$$

Note that $V(RM)$ is utility value when the JTYK is utilized and $V(SA)$ is utility value when the JTYK is not utilized. Since the physical meaning of utility is not clear, the difference between $V(RM)$ and $V(SA)$ is used to represent longevity risk alleviation. For comparisons, we

[7] For a description of the optimization model, see Yuh and Yang (2011).

[8] In this paper, we develop a computer code by using the programming language, C, to solve the problem. The program is run on a PC with an Intel® Xeon® CPU E5504, a clock-speed of 2 GHz, and 2.99 GB RAM.

normalize Y and introduce another measure YP. If $Y>0$ or $YP>0$, we may conclude that utilizing the JTYK is beneficial to the subject in terms of utility. Alternatively, if $Y<0$ or $YP<0$, we conclude that utilizing the JTYK is not beneficial to the subject in terms of utility.

3. Analysis

In order to analyze the effects of the JTYK on longevity risk alleviation of the JTYK, we obtained Y and YP for two cases: bequest is present and there is no bequest present. Then, ANOVA and regression analysis are used to identify the impact of retirement age of the householder, house value, net wealth exclusive of house value, and amount of public pension on the effect of longevity risk alleviation of the JTYK. The ANOVA is used in cases which other variables are not controlled, and the multiple regression analysis is used for the case where the other variables are controlled. Similar analysis can be found in Yang and Yuh (2014) and Yuh and Yang (2016).

4. Assumptions and Parameters

In this section, we discuss the assumptions and parameters used in this study.

1) Target Cohort and Retirement Age

Couples born between 1942-1952 were considered for this study. For simplicity, we assume that the ages of the husband and wife are the same. The retirement age is set to their current age and it is assumed that from that point, they live on their current wealth, public pension and JTYK income (without labor income).

2) CRRA (Coefficient of Risk Aversion, β)

We used β to represent coefficient of risk aversion. For this study, we set $\beta=1$ for the analysis.

3) Housing Cost for Self-annuitization Case

The self-annuitization case, in which it is assumed that a person optimally consumes their entire wealth, including the house, throughout their life without relying on any life annuities, always generates higher expected utility value from consumption than the case utilizing the JTYK. This is expected because the self-annuitization case does not consider the housing cost as a mandate expense. Alternatively, though JTYK borrowers receive somewhat smaller payouts from the KHFC than the self-annuitization case, they can live in their own house without paying any rent until death. Hence, in order to make the comparison valid we need to charge some rent to the couple who do not utilize the JTYK, as in Yang and Yuh (2014), and Yuh and Yang (2016). According to previous studies, if the total rent is between 30-50% of the value of the house, utilizing the JTYK is more beneficial to the individual than self-annuitization. Hence, we assume for convenience that the total rent for the couple without utilizing the JTYK spends 50% of their house value on rent[9]. Note that this study focuses more on the effects of various

[9] For example, in Korea a renter usually deposits money to the owner of the house about 60~80% of the house value, and then the renter can live at the house without any additional monthly rent. If the renter cannot deposit the

variables on longevity risk reduction rather than whether the JTYK is more beneficial to a couple than the self-annuitization. Hence, the total rent value does not have any impact on the ANOVA and the regression analysis.

4) Interest Rate, Bequest Intensity, and Other Parameters

We assume that the nominal interest rate, r, is 0.0227[10]. In accordance with the value used in Brown (2003), we established the utility discount rate, ρ, as 0.0227. The parameter, b, controls the intensity of the bequest motive; two different values for $b = 0$ and $b = 1$ are considered. Also, following Brown and Poterba's (2000) assumptions, the degree of jointness, λ, and the relative weights of the husband's and wife's utilities in the household utility aggregate, φ, are set to 0 and 1, respectively. The survivor ratio ϕ is 1 because the JTYK payout does not change after one partner becomes deceased.

IV. *Findings and Discussions*

1. Financial Analysis

First, we calculate the MWR, and the results are presented in Table 1. The results show that MWRs are all less than 1 and these results are expected because the MWR cannot consider the value of living in their own house. Considering the high housing costs in Korea as we discussed in subsection 3.4.3, MWRs around 0.5 is reasonably high, and we may conclude that the JTYK is financially valuable to elderly homeowners. Moreover, the financial value of the JTYK improves significantly if we consider the bequest as financial gain from the JTYK. The MWRs are larger than those without the bequest by 21%~47% depending on the JTYK payment type and opt-in age. Also, this difference generally increases as the opt-in age increases. For instance, if the JTYK is utilized at age 70, then the MWR is 0.8013 (fixed payment type), which is bigger than the MWR without bequest motives by about 47%. This is because the value from the bequest increases as age increases. Since MWRs without the bequest does not significantly change as ages vary, it can be assumed that the increase is mainly due to the additional value of the bequest. Figure 1 shows that MWRs with the bequest improves as age increases while MWRs without the bequest does not change as ages vary[11]. This result indicates that the JTYK is financially beneficial to the elderly homeowners as well as their heirs, and the financial value is getting higher as age increases.

In addition, among different types of the payment schemes, the preferential type generates the highest MWRs. However, the preferential type is only for the special case in which house value is less than about 0.136 million dollars. For general cases, the MWRs of the fixed payment type are slightly higher than those of the two-phase payment type if we consider the

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money, then he or she can pay 10~12% of the deposit as annual rent. Hence, in less than 20 years, the renter will spend as much as the house value as his/her monthly rent.

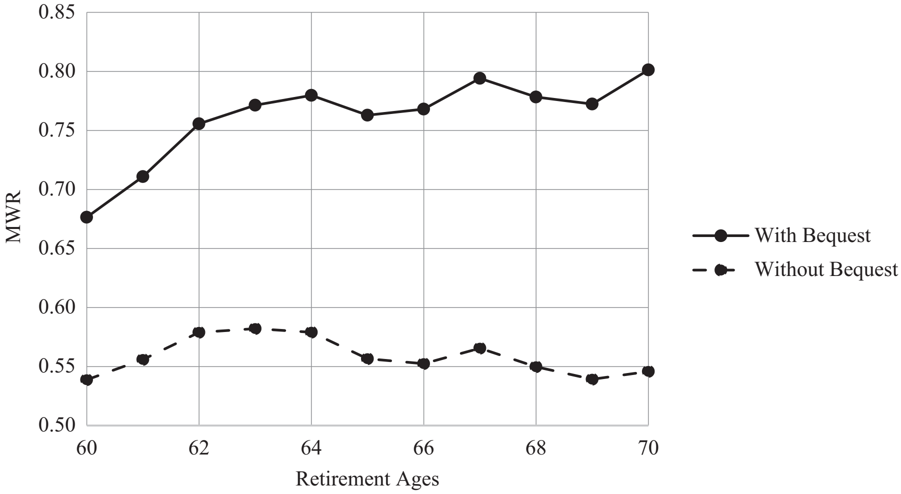
[10] This value is reasonable because the three year average (the second quarter, 2013 to the first quarter, 2016) of the 3-year Korea Treasury Bond (KTB) rate is 2.2987%, the three year average of the 91 days CD rate is 2.2300% and the three year average of saving account rate is 2.2892%.

[11] Notice that the increasing pattern is not smooth but somewhat fluctuates. We believe that the fluctuation may be due to errors while estimating cohort mortality rates.

TABLE 1. THE MWR BY RETIREMENT AGES WITH BEQUEST AND WITHOUT BEQUEST

	MW ratio with bequest			MW ratio without bequest		
age	fixed	two-phase	preferential	fixed	two-phase	preferential
60	**0.67642**	**0.63790**	**0.70694**	0.53876	0.51202	0.58257
61	**0.71090**	**0.67836**	**0.74212**	0.55598	0.53668	0.60124
62	**0.75562**	**0.73045**	**0.78822**	0.57897	0.56874	0.62745
63	0.77141	0.74616	0.80304	0.58212	0.57368	0.63085
64	0.77969	0.76017	0.81127	0.57905	0.58134	0.62864
65	0.76285	0.74153	0.79308	0.55666	0.55430	0.60537
66	0.76808	0.74793	0.79823	0.55243	0.55243	0.60173
67	0.79411	0.77368	0.82463	0.56551	0.56713	0.61682
68	0.77829	0.76047	0.80849	0.54980	0.55436	0.60045
69	0.77235	0.75637	0.80169	0.53927	0.54645	0.58967
70	0.80133	0.78517	0.82932	0.54588	0.55529	0.59848

FIGURE 1. THE MWR BY RETIREMENT AGES WITH BEQUEST AND WITHOUT BEQUEST FOR FIXED TYPE JTYK



bequest as financial gain from the JTYK. When the bequest is not considered, the differences between the two types seem negligible.

2. Utility-based Analysis (ANOVA)

As mentioned previously, two measures (Y and YP) regarding longevity risk alleviation were estimated and ANOVA (analysis of variance) was conducted to identify correlating factors. The results of ANOVA by retirement age are presented in Table 2. For both fixed payments and two-phase payments options, the measure Y, which is the utility differences between the case utilizing the JTYK and the case not utilizing the JTYK, is not significantly different by retirement age, while the measure YP, which is the utility percentage difference, is significantly different by retirement age. If we do not consider the bequest, then the alleviation

TABLE 2. ANOVA ON LONGEVITY RISK ALLEVIATION MEASURES (*Y* AND *YP*) BY AGE

bequest=0								
age (%)	fixed (Y)	F/ Pr>F	fixed % (YP)	F/ Pr>F	two-phase (Y)	F/ Pr>F	two-phase % (YP)	F/ Pr>F
60 (4.7)	4.87188	1.57	2.09455	2.54	4.33800	1.71	1.87115	2.79
61 (6.0)	2.83291	0.117	1.16643	0.0063	2.36991	0.0802	0.97228	0.0029
62 (3.4)	5.39465		2.67875	**	4.60671		2.26629	**
63 (6.8)	3.49207		1.49813		3.19217		1.36462	
64 (8.1)	3.17495		1.58368		2.72083		1.34434	
65 (11.5)	3.47092		1.87741		2.85732		1.53344	
66 (9.4)	3.22536		1.74727		2.81389		1.50998	
67 (12.8)	4.90174		2.80833		4.46537		2.54330	
68 (12.0)	4.42928		2.66429		3.93281		2.34541	
69 (12.8)	4.39311		2.60367		3.99717		2.36072	
70 (12.4)	4.12101		2.60103		3.81850		2.39633	
bequest=1								
age (%)	fixed (Y)	F/ Pr>F	fixed % (YP)	F/ Pr>F	two-phase (Y)	F/ Pr>F	two-phase % (YP)	F/ Pr>F
60 (4.7)	4.67149	1.62	1.97636	2.82	4.13372	1.81	1.75394	3.13
61 (6.0)	2.79441	0.103	1.13000	0.0026	2.32766	0.0608	0.93786	0.0009
62 (3.4)	5.18150		2.52500	**	4.38303		2.11407	***
63 (6.8)	3.44904		1.45438		3.13623		1.31911	
64 (8.1)	3.23941		1.58526		2.76907		1.34296	
65 (11.5)	3.57349		1.89481		2.94086		1.54771	
66 (9.4)	3.35521		1.78182		2.92333		1.53990	
67 (12.8)	4.96917		2.78633		4.49604		2.50637	
68 (12.0)	4.55638		2.68821		4.03410		2.36124	
69 (12.8)	4.54306		2.63367		4.11897		2.37930	
70 (12.4)	4.30322		2.64655		3.96020		2.42265	

effect increases from age 67 and older in the fixed payment option. A similar pattern was observed in the two-phase option, but the degree of the alleviation effect was slightly decreased. A large age effect from age 67 and older on longevity risk alleviation was observed when we consider the bequest. Compared to the case without the bequest, the alleviation effect was larger when the bequest is considered in both payment options from ages 68-70. This result suggests that the longevity risk alleviation effect measured in utility is especially strong for elderly aged 67-70, and even stronger when considering the bequest in the valuation of JTYK.

The results of the ANOVA by house value are presented in Table 3. The measures *Y* and *YP* significantly differ by house value, both with and without the bequest motive.

In the fixed payment option, the measure *Y* is the highest for the 4th quarter group (Q4) of the house value, followed by Q2, Q3, and Q1. Similarly, compared to Q1 and Q3, the 2nd quarter group (Q2) and the 4th quarter group (Q4) have much higher values of *YP* (2.58, 2.53 vs. 1.80, 1.90, respectively), which is the utility percentage differences.

A similar pattern can be found in the two-phase option such that *YP* is higher for the Q2 and Q4 groups, with the highest value from Q4. However, *Y* consistently increased with house value in the two-phase option. This implies that the longevity risk decreases for those who have higher house values.

In both payment options, values of *Y* are higher for the Q1, Q2, and Q3 groups with the

Table 3. ANOVA on Longevity Risk Alleviation Measures (Y and YP) by House Value

house value	fixed (Y)	F/ Pr>F	fixed % (YP)	F/ Pr>F	two-phase (Y)	F/ Pr>F	two-phase % (YP)	F/ Pr>F
bequest=0								
Q1	2.91428	8.42	1.79836	3.71	2.25489	13.1	1.39866	5.24
Q2	4.45743	<.0001	2.58000	0.0123	3.51667	<.0001	2.04982	0.0016
Q3	3.53561	***	1.90037	*	3.51847	***	1.90002	**
Q4	5.15614		2.52897		5.03867		2.47675	
bequest=1								
house value	fixed (Y)	F/ Pr>F	fixed % (YP)	F/ Pr>F	two-phase (Y)	F/ Pr>F	two-phase % (YP)	F/ Pr>F
Q1	3.05200	7.62	1.84672	3.2	2.38883	11.96	1.45247	4.36
Q2	4.52398	<.0001	2.56836	0.0241	3.57962	<.0001	2.04518	0.0052
Q3	3.64516	***	1.91870	*	3.58212	***	1.89394	**
Q4	5.13376		2.46897		4.97193		2.39545	

Table 4. ANOVA on Longevity Risk Alleviation Measures (Y and YP) by Net Wealth

NW excl. house	fixed (Y)	F/ Pr>F	fixed % (YP)	F/ Pr>F	two-phase (Y)	F/ Pr>F	two-phase % (YP)	F/ Pr>F
bequest=0								
Q1	5.20355	10.9	3.01176	16.09	4.70562	10.41	2.70722	15.25
Q2	4.11270	<.0001	2.45656	<.0001	3.46622	<.0001	2.06952	<.0001
Q3	3.33989	***	1.75150	***	2.92618	***	1.52960	***
Q4	2.90092		1.34526		2.59365		1.20168	
bequest=1								
NW excl. house	Fixed (Y)	F/ Pr>F	fixed % (YP)	F/ Pr>F	two-phase (Y)	F/ Pr>F	two-phase % (YP)	F/ Pr>F
Q1	5.40224	15.4	3.06329	21.07	4.85035	14.33	2.73575	19.91
Q2	4.29848	<.0001	2.51250	<.0001	3.62686	<.0001	2.11897	<.0001
Q3	3.38529	***	1.73667	***	2.95301	***	1.50962	***
Q4	2.75214		1.24825		2.46250		1.11653	

bequest motive than those without the bequest motive. This suggests that the longevity risk is decreased when homeowners consider the bequest in the valuation of JTYK. Overall, longevity risk reduction is greatest for those who have the highest house values, both with and without the bequest motive.

The results of the ANOVA by net wealth excluding house value are presented in Table 4. The longevity risk alleviation of the JTYK significantly differs by level of net wealth. In all cases, we find both Y and YP decreased with the increase of net wealth excluding house value. Those with less net wealth have greater longevity risk alleviation effects from the JTYK with and without the bequest motive. For instance, Y of Q1 (5.40) is about two times higher than that of Q4 (2.75) when the bequest is considered in the fixed option. When the bequest is considered, Y is consistently higher for the Q1, Q2, and Q3 groups, and YP is higher only for the Q1 and Q2 groups in both options. This implies that the longevity risk alleviation from the JTYK is greater for those with less net wealth and considering the bequest. Therefore, the

Table 5. ANOVA on Longevity Risk Alleviation Measures (*Y* and *YP*) by Public Pension

				bequest=0				
public pension	Fixed (Y)	F/ Pr>F	fixed % (YP)	F/ Pr>F	two-phase (Y)	F/ Pr>F	two-phase % (YP)	F/ Pr>F
Q1	**6.91461**	105	**3.97763**	111.82	**6.15934**	75.15	**3.52996**	86.71
Q2	4.76464	<.0001	2.70288	<.0001	4.15724	<.0001	2.34378	<.0001
Q3	3.00944	***	1.54254	***	2.65739	***	1.36346	***
Q4	1.28108		0.54772		1.20774		0.51955	
				bequest=1				
public pension	Fixed (Y)	F/ Pr>F	fixed % (YP)	F/ Pr>F	two-phase (Y)	F/ Pr>F	two-phase % (YP)	F/ Pr>F
Q1	6.78899	94.71	3.84559	100.14	6.00683	69.52	3.38960	80.17
Q2	**4.89768**	<.0001	**2.73322**	<.0001	**4.26270**	<.0001	**2.36633**	<.0001
Q3	**3.14625**	***	**1.58627**	***	**2.77734**	***	**1.40186**	***
Q4	**1.43138**		**0.60333**		**1.33538**		**0.56591**	

Table 6. Regressions on Longevity Risk Alleviation Measures (*Y* and *YP*) by Bequest

				bequest=0				
	fixed (Y)		fixed % (YP)		two-phase (Y)		two-phase % (YP)	
	estimate	sig.	estimate	sig.	estimate	sig.	estimate	sig.
intercept	5.52225	*	-2.27610		2.47250		-3.30828	*
age	-0.01645		0.07550	**	0.01592		0.08306	***
house value	0.00833	***	0.00337	***	0.00994	***	0.00432	***
NW excl. house	-0.00478	***	-0.00317	***	-0.00468	***	-0.00304	***
public pension	-0.14528	***	-0.08131	***	-0.12836	***	-0.07162	***
R-square	0.5931		0.5336		0.6193		0.5544	
F	83.45	***	65.5	***	93.14	***	71.22	***
				bequest=1				
	fixed (Y)		fixed % (YP)		two-phase (Y)		two-phase % (YP)	
	estimate	sig.	estimate	sig.	estimate	sig.	estimate	sig.
intercept	3.17730		-3.32751	*	0.37840		-4.20091	**
age	0.02049		0.09158	***	0.04899		0.09682	***
house value	0.00814	***	0.00318	***	0.00956	***	0.00402	***
NW excl. house	-0.00557	***	-0.00350	***	-0.00529	***	-0.00327	***
public pension	-0.13778	***	-0.07662	***	-0.12087	***	-0.06702	***
R-square	0.6056		0.5502		0.6336		0.5728	
F	87.92	***	70.04	***	99.01	***	76.77	***

JTYK is beneficial for the group with low levels of net wealth excluding house, and this seems consistent with the JTYK's original purpose.

The results of the ANOVA by public pension level are presented in Table 5. Longevity risk alleviation significantly differs by the amount of public pension income received. In all cases, both *Y* and *YP* consistently decrease with increased public pension income, and the pattern is clearer than in the previous case of net wealth. Those with less public pension income have greater longevity risk alleviation effects from the JTYK with and without the bequest motive. For example, *Y* of Q1 (6.91) is about 5.4 times higher than that of Q4 (1.28) when the bequest is not considered in the fixed option. Except for Q1, the higher risk alleviation effects were found in Q2, Q3, and Q4 when we consider the bequest. That is, the JTYK provides greater benefits for longevity risk alleviation for those with the bequest motive, except for those with the lowest level of public pension (Q1). For those receiving the lowest public pension incomes, the alleviation effects are higher without the bequest motive than in the other case. Overall, the JTYK is more beneficial for the group with the low level of public pension income. In addition, the alleviation effect are higher in the fixed option than the two-phase option.

3. Determinants of Longevity Risk Alleviation Effects

Regression analysis was performed to identify major determinants of the longevity risk alleviation from the JTYK, and results are shown in Table 6. Regardless of considering the bequest, the major determinants of the alleviation are retirement age, house value, net wealth excluding house, and public pension. Controlling for the other factors, each of the four factors has an independent impact on alleviating the longevity risk from the JTYK.

Under the fixed option, house value, net wealth, and public pension are major determinants of *Y* with and without the bequest motive. Those with higher house values, lower net wealth, and lower public pension incomes receive greater benefits from the JTYK in alleviating longevity risk. For *YP*, retirement age is a significant factor in addition to the three factors addressed above. That is, those with a higher retirement age have higher values of *YP* and receive greater benefits from the JTYK. In terms of relative size of the estimate, retirement age and amount of public pension income significantly alleviate longevity risk for both *Y* and *YP*.

Similar patterns are found with the two-phase option. House value, net wealth, and public pension are major determinants of *Y*, and age is added as an additional determinant of the *YP* measure. That is, those with higher house values, lower net wealth, and lower public pension incomes receive greater benefits from the JTYK in alleviating longevity risk. These three determinants are found in both *Y* and *YP*, but retirement age is only significant for *YP*. That is, older homeowners receive greater benefits for alleviating longevity risk by using the JTYK with and without the bequest motive. In terms of relative size of the estimate, public pension income has the largest effect on *Y*, while retirement age has the largest effect on *YP* under the two-phase option. Overall, results are consistent with previous studies.

V. *Summary and Policy Implications*

The objective of this study is to examine how longevity risk can be alleviated by using the reverse mortgage loan system in Korea (the JTYK). In contrast to previous studies, we considered the bequest motive in the analysis model. We compared expected utility value of JTYK borrowers during the retirement period with that of non-JTYK users, and identified characteristics of groups receiving the greatest benefits from the JTYK in terms of the expected utility value. The group of households receiving the greatest benefits from the JTYK was identified by age, net wealth, housing value, public pension income, and bequest motives. In addition, we also calculate the MWR of the JTYK to evaluate

The results of this study can be summarized as follows: First, MWRs are all less than 1 and these results are expected because the MWR cannot consider the value of living in their own house. Moreover, considering the high housing costs in Korea, we may conclude that the JTYK is financially valuable to elderly homeowners. Results imply that the JTYK is beneficial for the elderly with older ages in terms of the financial value if the bequest value is considered as financial gain. Second, we compare the expected utility value of the JTYK borrowers during the retirement period with that of non-JTYK borrowers. The results imply that the JTYK is particularly beneficial for homeowners aged 67 and older when considering the bequest value. This is due to the higher bequest value resulting from shorter payment periods associated with older JTYK borrowers, and hence, greater residual house value remaining following the expiration of the homeowner. Hence, the JTYK should be encouraged for the elderly with strong bequest motives. Third, this study found that the longevity risk alleviation from the JTYK is affected by several crucial factors. Controlling for other factors, the alleviation was significantly influenced by the value of house, net wealth excluding the house value, retirement age of the householder, and public pension changes. Specifically, the alleviation effects increase as the value of house and age of the householder increase, but the effects decrease as net wealth excluding the house value and public pension increase.

The JTYK will certainly play an important role in supplementing insufficient regular income of elderly households in the aged society of Korea. As life expectancy continues to rise and millions of baby-boomers approach retirement age, it is crucial for better understanding of the reverse mortgage market and the extent to which reverse mortgages may facilitate consumption smoothing in retirement. We believe that the results of this study help retirees, such as elderly homeowners, understand properties of the JTYK better and provide insights for effective strategies based on age, house value, net wealth, and public pension income amounts when considering the JTYK.

We believe that the study contributes to the future improvement of the JTYK to alleviate longevity risk more effectively. The primary target group of the JTYK is elderly homeowners with low income and limited wealth. Our results indicate that those who benefit most from the JTYK include the elderly who own relatively high-valued homes with limited assets. Hence, our results are consistent with the original intention of the design of the JTYK system. Hence, policy makers need to continue to evaluate their target groups and revise when necessary. Also, the results of this study suggest that the housing costs during retirement is a crucial factor when individuals consider the JTYK and policy makers must improve the design of the JTYK. Therefore, housing costs during retirement, including future housing prices, should be more carefully forecasted and applied to the JTYK system.

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